## DISCUSSION

Long-term effects of grazing, recreational activities, and habitat fragmentation on populations and communities can include changes in abundance, distribution, and demographics of populations, or changes in interactions and species composition of bird communities (cf. Knight and Cole 1995a). With disturbances by livestock and recreationists I predicted changes in overall species richness, diversity, evenness, and turnover, but these factors remained fairly constant in all areas along the South Fork of the Snake River. On average, species numbers and relative abundance appeared to be most reduced by recreational activities except in large patches managed for recreation. Although species composition differed between grazed and unmanaged sites, few statistical differences were found in overall mean number of species or mean number of individuals per survey visit.

Distribution and relative abundance of individual species, species grouped by nest layer, and species grouped by nest type, however, varied significantly among land-use activities and patch sizes. Abundances of birds nesting in canopy, shrub, and ground layers were positively correlated with abundance of these structural components of the vegetation. Timing and intensity of livestock grazing (Bock et al. 1993a, Milchunas and Lauenroth 1993, Saab et al. 1995) and recreational uses (van der Zande et al.1984, Knight and Cole 1995b) can have differential effects on plant and animal communities. Because these factors were not controlled, and varied within my study sites, some effects of grazing and recreational activities on bird community characteristics may have been masked.

Vegetation characteristics were most similar between recreation and unmanaged sites, yet overall bird abundance was lowest in recreation campgrounds. This suggests that additional factors, most likely the presence and activities of humans, may have had a prevailing influence on patterns of bird microhabitat use within recreational areas. If recreational disturbance is a primary reason for reduced abundances, then we need to know the relationships between disturbance, long-term persistence of avian populations, reproduction, and survival.

Wildlife responses to recreational disturbance are influenced by many factors, including the type of activity (e.g., motorized vs. nonmotorized), recreationist's behavior (e.g., slow vs. rapid movement), predictability (e.g, consistent vs. erratic), and timing (e.g., breeding season vs. nonbreeding) (Hockin et al. 1992, Knight and Cole 1995b). Little information is available about the consequences of these different influences on birds (Knight and Cole 1995a). However, greater impacts have generally been reported for recreation that is motorized (e.g., Titus and VanDruff 1981), rapid moving (e.g., Burger 1981), unpredictable (e.g., Klein 1993), and prevalent during the breeding season (e.g., Hockin et al. 1992). Most of the recreational activities within my study sites were nonmotorized and slow moving (camping, hiking, and fishing), and consistent only on weekends throughout the breeding season.

Other studies have evaluated recreational effects on bird community structure by comparing the avifaunal use of undeveloped areas and sites variously developed as campgrounds (Aitchison 1977, Foin et al. 1977, Robertson and Flood 1980, Clark et al. 1984, Blakesley and Reese 1988). Most of these studies generally found a higher species diversity in disturbed habitats, which was mainly due to additional, common opportunistic species moving into recreation areas, while some other species were reduced or eliminated by recreational development. One study reported lower bird species diversity and evenness in recreational developments but greater overall abundance than undeveloped sites, while species richness was similar between the two areas (Robertson and Flood 1980). Studies of recreation effects on bird populations in the Netherlands found that most species had significantly lower densities in developed parks with heavy recreational use (van der Zande and Vos 1984, van der Zande et al. 1984).

Along the South Fork of the Snake River, overall abundance was significantly reduced in recreation areas, while species richness and composition were similar among land-use types. Only one species (Warbling Vireo) experienced significant increases in abundance within campgrounds, whereas five species (Mourning Dove, Dusky Flycatcher, Black-billed Magpie, House Wren, and European Starling) responded positively in areas managed for grazing. Warbling Vireos generally placed their nests high in the canopy layer, which was unaffected by land-use activities (at least over the short-term) and relatively distant from recreationists. Most species with increased abundances in grazed lands are noted for using human-altered habitats (e.g., Saab 1999, Rodenhouse et al. 1995, Saab et al. 1995).

In a review of nine studies that evaluated avian responses to livestock grazing in riparian habitats (Saab et al. 1995), nearly half (46%) of 68 neotropical migrant landbirds decreased in abundance with cattle grazing, 9% increased with grazing, and 25% showed no clear response. Grouped either by nest placement or nest type, ground-nesting birds (including Veery and Fox Sparrow) were most negatively affected by livestock grazing, whereas canopy- and cavity-nesting species were least affected by grazing activities over the short-term. Results of this study were consistent with these findings.

I found that ground-nesting species were most susceptible to disturbances created by livestock grazing and were also most sensitive to fragmentation of riparian habitats, i.e. their relative abundances decreased with decreasing patch size. This is consistent with studies of habitat fragmentation in deciduous forests of eastern and mid-western United States (see Askins et al. 1990, Faaborg et al. 1995). Species that are more abundant on large fragments tend to be long-distance neotropical migrants rather than short-distance migrants or residents, generally nest on or near the ground, and use open rather than cavity nests (Whitcomb et al. 1981, Martin 1988, Faaborg et al. 1995). In this study, both Veery and Fox Sparrow were long-distance neotropical migrants that placed their open-cup nests (and foraged) on or near the ground. These ground nesters were probably more vulnerable to nest losses, and reductions in foraging habitat through the physical removal and damages to ground vegetation in grazed areas.

Factors affecting ground nesters in small fragments can include habitat alterations due to changes in microclimate conditions (cf. Faaborg et al.1995). Temperature and evaporation rates were higher next to openings than within continuous tropical forest (Lovejoy et al.1986). Such changes have been found to extend 30 to > 240 m into temperate forests of the Pacific Northwest United States (Chen et al. 1995).

Shrub nesters might be sensitive to changes resulting from livestock grazing and recreational activities, based on near significant ($p = 0.11$) decreases in their abundances as compared to unmanaged sites. Within grazed and recreation sites, microhabitats of shrub nesters were severely altered by significant reductions of shrub cover and densities, and increases in bare ground. By reducing foliage densities or opening dense patches of vegetation, cattle or campgrounds may increase nest losses by exposing concealed nests to predators (e.g., black-billed magpies) and allowing predator access. These results are consistent with regional trends. From 1968-1994 within the interior Columbia River Basin (which includes all of Idaho) species with decreasing populations tended to be those nesting in the shrub layer, whereas species with increasing populations tended to nest in tree canopies (Saab and Rich 1997). In forested habitats, songbirds that nest in shrubs generally experience the highest rates of nest predation (Martin 1993, Martin 1995), a factor that may be contributing to decreasing population trends within the region.

Mourning Dove, Yellow Warbler, and Song Sparrow are shrub-nesting species experiencing long-term population declines in the region (interior Columbia River Basin [Saab and Rich 1997]). Their abundances were significantly reduced with either local grazing, recreational activities, and/or small habitat fragments within my study area. Local land-use practices could be working in synergistic ways to cause widespread, regional declines within these species.

Canopy-nesting species tended to increase in grazed habitats as compared to recreation or unmanaged areas. Regionally, canopy nesters as a group experienced long-term population increases from 1968-1994 (Saab and Rich 1997). Few species in this group were affected by patch size along the South Fork. Additionally, the microhabitat feature of tree canopy coverage was similar among land uses, indicating that other factors were influencing patterns of habitat use by canopy nesters. A significant negative correlation was found between canopy nesters (which showed increases in grazed areas) and ground nesters (which showed decreases in grazed areas), suggesting that changes in interactions of the bird community could be affected by habitat modifications.

All cavity nesters were classified as nesting in the canopy and, when analyzed separately, they showed similar trends as canopy nesters. These results corroborate those of individual studies that examined short-term grazing effects on cavity nesters (see Saab et al.1995), and concluded that woodpeckers and other cavity-nesting species were relatively unaffected and sometimes increased in grazed habitats. Cavity-nesting birds place their nests in snags and dead limbs, and frequently forage in tree locations (bark) that are generally not used by cattle.

Relative abundances of Veeries and Fox Sparrows were reduced by half in recreation campgrounds compared to unmanaged sites, and both species were nearly absent from grazed areas. Fox Sparrows were associated with undeveloped sites when compared to campgrounds in riparian habitats of Utah (Blakesley and Reese 1988). In this Utah study, open-ground foragers such as American Robin and Gray Catbird were associated with campgrounds (although this was not statistically significant). These species were possibly attracted to food sources created by humans, whereas more wary species such as the Fox Sparrow avoided human activities (Garton et al.1977). Abundances of American Robins and Gray Catbirds in my study area appeared unaffected by recreational activities.

Veeries tended to use larger cottonwood patches (Saab 1999), particularly in recreation areas with campgrounds. Research in the Midwest and eastern United States has shown that Veeries are sensitive to reductions in sizes of forest patches, and avoid relatively small forest tracts (Robbins 1980, Robbins et al. 1989b, Herkert 1995). The Veery is experiencing significant population declines throughout the North American continent (Peterjohn et al. 1995). Habitat fragmentation, cattle grazing, and recreational activities within riparian systems could be factors contributing to their population declines in the western United States.

Five species, including Veeries, were unaffected by patch size in unmanaged areas with minimal use by humans or cattle, but showed significant area effects (increases in probability of occurrence with cottonwood forest area) in grazed and/or recreation sites. Perhaps larger patches of cottonwood riparian forests are required in disturbed areas (of relatively poor habitat quality) for these species to obtain all the resources needed for reproduction and survival. Small habitat patches disturbed by cattle or recreationists could be functioning as population "sinks," where reproduction does not compensate for adult mortality (Brown and Kodric-Brown 1977, Pulliam 1988). Alternatively, large patches might be acting as population "sources," where reproduction equals or exceeds adult mortality (Pulliam 1988).

## MANAGEMENT IMPLICATIONS AND RESEARCH NEEDS

More than any other habitat in western North America, riparian woodlands are centers of high diversity and abundance of birds (Bock et al.1993a). Livestock grazing and recreation are concentrated within western riparian habitats, and many landbirds have responded negatively to these activities. Livestock grazing is the most widespread economic use of public lands in western North America (Platts 1991), while recreational activities continue to increase on shrinking land bases (Knight and Temple 1995). In the absence of effective management, these influences are likely to become more problematic for native plant and animal species.

Management practices often used to control recreational use of natural areas include collecting user fees, restricting visitor behavior and access, requiring permits based on specific qualifications, zoning, educating the public, limiting the number of visitors, and periodic closing (see van der Zande et al. 1984, Klein et al. 1995). Limiting visitor access and allowing the intensity of already busy areas to increase, rather than allowing visitor intensity to spread will likely reduce impacts to breeding birds (van der Zande et al. 1984). Along the South Fork of the

Snake River, the heaviest recreational use is during the breeding season, so periodic closing may not be an appropriate practice. Constraining the behavior of visitors is a viable management option because such things as noise, speed, and type of recreational activity elicit different responses from wildlife (Klein 1993). Aspects of these categories could be altered to minimize the impacts of recreationists. If noise and movement of recreationists could be reduced, there would be an increased likelihood of coexistence (Knight and Temple 1995). A lack of information on how human behavior affects wildlife has kept the usefulness of this coexistence strategy from being applied (Knight and Temple 1995).

The condition of riparian areas must be considered critically when implementing grazing systems, and, when practical, riparian woodlands should be managed separately from adjacent uplands (Platts 1991). Given their scarcity, fragility, and importance to landbirds and other wildlife, western riparian ecosystems should be excluded from livestock grazing wherever possible. Few bird species appear to benefit from grazing in these habitats, and those that do are not restricted to riparian communities (this study, Saab et al. 1995). Based on available information, when riparian systems are grazed, moderate use during late-fall and winter, or short-term use in spring, will be less damaging than continuous or growing-season grazing (Saab et al. 1995). Fall-winter grazing should be carefully controlled to ensure the maintenance of residual plant cover.

Degraded riparian habitats may require complete rest from livestock grazing to initiate the recovery process. The establishment of large protected areas (ca. 1000 ha) are needed to serve as references for comparison with managed sites (cf. Bock et al. 1993b). Four years after cattle removal from riparian habitat in Arizona, understory vegetation and Neotropical migrants showed dramatic increases in abundance (Krueper 1993). In systems requiring long-term rest, the necessary period will be highly variable depending upon the extent of damage and growth rate of regenerating plant species (Clary and Webster 1989). Damaged riparian areas should be rehabilitated by revegetating with native species.

Riparian habitats of arid land western North America have unique features among forests (i.e., linear, narrow shapes with large amounts of edge) and are often naturally fragmented. Yet some species could be characterized as large patch, interior specialists (e.g.,Veery), and others are clearly edge specialists (e.g., Song Sparrow). Thus, management considerations should include conservation of both large (> 10 ha in cottonwood woodlands) and small patches, although small patch/edge habitats usually are not limiting. Conservation of large patches is particularly important where riparian forests are managed for grazing and recreation. Some species apparently need larger patches of breeding habitat in areas with these disturbances.

Further research is needed to improve our understanding of the relationships between landbirds and land-use practices in riparian ecosystems. Studies designed to evaluate the types, timing, and intensity of grazing and recreational activities are needed to determine the degree of intolerance or habituation of the birds. No information is available on the synergistic effects of grazing and recreation, and this is critically needed because these land-use activities frequently occur together in the western United States. If grazing and recreational disturbance are responsible for individuals leaving an area, we need to know where they go and what habitats they use, and the relationships of riparian habitats to other parts of the landscape that support riparian birds during the breeding season. Avian abundance data may not always reflect habitat suitability (Van Horne 1983). Long-term studies on reproductive success, survivorship, and population persistence are needed in riparian habitats under different management regimes.

## LANDSCAPE INFLUENCES AND MANAGEMENT IMPLICATIONS

Information presented in the previous sections was part of a multi-study project to evaluate the effects of smaller-scale management practices and larger-scale landscape patterns on habitat relationships of breeding birds in cottonwood forests (Saab 1996). This section is summarized from Saab (1999) and provides a synopsis on the relative importance of landscape patterns to habitat use by breeding birds.

A hierarchical approach was used to examine habitat use at three spatial scales: microhabitat (local vegetation characteristics), macrohabitat (cottonwood forest patch characteristics), and landscape (composition and patterning of surrounding [matrix] vegetation types and land uses). A series of predictions regarding distributions of 32 species were addressed that incorporated the different spatial scales. The surrounding landscape changed from a valley surrounded by mountains on the upstream end of the study area, a narrow canyon adjacent to natural upland vegetation in the middle section, to a wide, open floodplain dominated by agriculture on the downstream end. The best predictors of high species richness of the native avifauna were: (1) natural and heterogeneous landscapes, (2) large cottonwood patches, (3) close proximity to other cottonwood patches, and (4) microhabitats with relatively open canopies. The most frequent significant predictor of species occurrence was the landscape component - increases in upland natural vegetation with decreases in agriculture. Both habitat interior and edge specialists were found in arid land, cottonwood riparian forests that are linear in nature with large amounts of edge. Nest predators (black-billed magpie and American crow), brood parasites (brown-headed cowbird), and exotic species (European starling) responded positively to human-altered landscapes. Landscape patterns were the primary influence on distribution and occurrence of most bird species, while macrohabitat and microhabitat were of secondary importance. Thus, surrounding landscape (matrix) features should be a primary consideration for managing riparian habitats and selecting riparian reserve areas.

Land acquisition and maintenance of large cottonwood patches surrounded by natural landscapes should take precedence over conserving large patches surrounded by agriculture if maintaining high species richness of native birds is a management objective. Conservation of contiguous patches of cottonwood forest adjacent to palustrine wetlands is also desirable for many individual species and for maintenance of species richness. Both large and naturally small fragments of riparian habitat are needed for conservation of interior and edge specialists. Small patches, generally are not limiting in arid-land riparian habitats, but those that exist should be conserved for bird species associated with edge habitats. Management objectives for natural landscapes should consider controlling residential growth to reduce the likelihood of avian nest predators (i.e., crows and magpies) and exotic species (i.e., starlings). Among microhabitat characteristics, a relatively open cottonwood forest canopy was the most important predictor of high species richness and of occurrence for several species. This microhabitat feature may reflect pre-dam conditions, when natural flooding disturbances created more patchiness in the mature forest canopy interspersed with younger cottonwood stands (cf. Merigliano 1996). Flood control can greatly alter riparian plant communities by increasing cover of plant species that would otherwise be removed by flood scour, causing plant desiccation, reduced growth, competitive exclusion, ineffective seed dispersal, or failure of seedling establishment (see Poff et al. 1997). The magnitude and timing of peak flows should approximate pre-dam conditions for the long-term maintenance of cottonwood forests (Rood and Heinze-Milne 1989, Johnson 1992, Merigliano 1996) and the associated bird community.

## LITERATURE CITED


Aitchison, S.W. 1977. Some effects of a campground on breeding birds in Arizona. In: Johnson, R.R., and D.D. Jones. eds. Proceedings on importance, preservation and management of riparian habitat: a symposium. USDA Forest Service, Gen. Tech. Rep. RM-43. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO:172-182.

Askins, R.A., J.F. Lynch, and R. Greenberg. 1990. Population declines in migratory birds in Eastern North America. Current Ornithol. Vol. 7:1-57.

Blakesley, J.A., and K.P. Reese. 1988. Avian use of campground and noncampground sites in riparian zones. J. Wildl. Manage. 52:399-402.

Bock, C.E., and B. Webb. 1984. Birds as grazing indicator species in southeastern Arizona. J. Wildl. Manag. 48:1045-1049.

Bock, C.E., V.A. Saab, T. Rich, and D.S. Dobkin, D.S. 1993a. Effects of livestock grazing on neotropical migratory landbirds in western North America. In: Finch, D.M.; P.W. Stangel, eds. Status and management of neotropical migratory birds; 1992 September 21-25; Estes Park, CO. Gen. Tech. Rep. RM-229. Fort Collins, CO: USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station:296-309.

Bock, C.E., J.H. Bock, and H.M. Smith. 1993b. Proposal for a system of federal livestock exclosures on public rangelands in the western United States. Conservation Biology 7:731-733.

Boyle, S.A., and F.B. Samson. 1985. Effects of nonconsumptive recreation on wildlife: a review. Wildl. Society Bull. 13:110-116.

Brown, J.H, and A. Kodric-Brown. 1977. Turnover rates in insular biogeography:effect of immigration and extinction. Ecology 58:445-449.

Burger, J. 1981. The effect of human activity on birds at a coastal bay. Biological Conservation 21:231-241.

Carothers, S.W., and R.R. Johnson. 1975. Water management practices and their effects on nongame birds in range habitats. Pages 210-222 in: D.R. Smith, editor. Symposium on management of forest and range habitats for nongame birds. USDA Forest Service Gen. Tech. Rep. WO-1. Washington, DC, USA.

Chen, J., J.F. Franklin, and T.A. Spies. 1995. Growing-season microclimatic gradients from clearcut edges into old-growth Douglas-fire forests. Ecological Applications 5:74-86.

Clark, K.L., D. Euler, and E. Armstrong. 1984. Predicting avian community response to lakeshore cottage development. J. Wildl. Manag. 48:1239-1247.

Clary, W.P., and B.F. Webster. 1989. Managing grazing of riparian areas in the Intermountain Region. USDA Forest Service Gen. Tech. Rep. INT-263, Intermountain Research Station, Ogden, UT.

Cody, R.P. and J.K. Smith. 1991. Applied statistics and the SAS programming language, 3rd ed. Elsevier Science Publishing Co., Inc., New York, NY.

Donovan, T.M., F.R. Thompson, J. Faaborg, and J.R. Probst. 1995. Reproductive success of migratory birds in habitat sources and sinks. Conservation Biology 9:1380-1395.

Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. The birders handbook--a guide to the natural history of North American birds. Simon & Schuster Inc., New York. 785 p.

Faaborg, J., M. Brittingham, T. Donovan, and J. Blake. 1995. Habitat fragmentation in the Temperate Zone. In: Finch, D.M.; Martin, T.E. eds. Ecology and management of neotropical migratory birds: a synthesis and review of critical issues. Oxford Univ. Press:357-380.

Finch, D.M. 1991. Population ecology, habitat requirements, and conservation of neotropical migratory birds. USDA Forest Service, Gen. Tech. Rep. RM-205.

Finch, D.M. and P.W. Stangel (eds.). 1993. Status and management of Neotropical migratory birds. USDA Forest Service Gen. Tech. Rep. RM-229. Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 422 p.

Flather, C.H., and H.K. Cordell. 1995. Outdoor recreation: historical and anticipated trends. In: Knight, R.L., and K.J. Gutzwiller. eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C.:3-16.

Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8:629-644.

Foin, T.C., E.O. Garton, C.W. Bowen, J.M. Everingham, R.O. Schultz, and B. Holton. 1977. Quantitative studies of visitor impacts on environments of Yosemite National Park, California, and their implications for park management policy. J. Environmental Manag. 5:1-22.

Freemark, K.E., J.B. Dunning, S.J. Hejl, and J.R. Probst. 1995. A landscape ecology perspective for research, conservation, and management. In: Finch, D.M.; Martin, T.E. eds. Ecology and management of neotropical migratory birds: a synthesis and review of critical issues. Oxford Univ. Press:381-427.

Garton, E.O., B. Hall, and T.C. Foin. 1977. The impact of a campground on the bird community of a lodgepole pine forest. In: Foin, T.C. ed. Visitor impacts on national parks: the Yosemite ecological impact study. Inst. Ecol., Univ. California, Davis, Publ.10:37-43.

Gutzwiller, K.J., and S.H. Anderson. 1987. Multiscale associations between cavity-nesting birds and features of Wyoming streamside woodlands. Condor 89:534-548.

Hagan, J.M., and D.W. Johnston (eds.). 1992. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington, DC. 609 p.

Haila, Y., I.K. Hanski, and S. Raivio. 1993. Turnover of breeding birds in small forest fragments: the "sampling" colonization hypothesis corroborated. Ecology 74:714-725.

Herkert, J.R. 1995. Status and habitat area requirements of the Veery in Illinois. Auk 112:794-797.

Hockin, D., M. Ounsted, M. Gorman, D. Hill, V. Keller, and M.A. Barker. 1992. Examination of the effects of disturbance on birds with reference to its importance in ecological assessments. J. Environmental Manag. 36:253-286.

James, F.C., and H.H. Shugart. 1970. A quantitative method of habitat description. Audubon Field Notes 24:727-736.

Klein, M.L. 1993. Waterbird behavioral responses to human disturbances. Wildl. Society Bull. 21:31-39.

Klein, M.L., S.R. Humphrey, and H.F. Percival. 1995. Effects of ecotourism on distribution of waterbirds in a wildlife refuge. Conservation Biology 9:1454-1465.

Knight, R.L., and D.N. Cole. 1995a. Wildlife responses to recreationists. In: Knight, R.L., and K.J. Gutzwiller. eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C.:51-69.

Knight, R.L., and D.N. Cole. 1995b. Factors that influence wildlife responses to recreationists. In: Knight, R.L., and K.J. Gutzwiller. eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C.:71-79.

Knight, R.L., and K.J. Gutzwiller. 1995. Wildlife and recreationists. Island Press. 372 p.

Knight, R.L., and S.A. Temple. 1995. Wildlife and recreationists: coexistence through management. In: Knight, R.L., and K.J. Gutzwiller. eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C.:71-79.

Knopf, F.L., R.R. Johnson, T.D. Rich, Sampson, F.B. and R.C. Szaro. 1988a. Conservation of riparian ecosystems in the United States. Wilson Bulletin 100:272-284.

Knopf, F.L., J.A. Sedgwick, and R.W. Cannon. 1988b. Guild structure of a riparian avifauna relative to seasonal cattle grazing. J. Wildl. Manag. 52:280-290.

Krueper, D.J. 1993. Effects of land use practices on western riparian ecosystems. In: Finch, D.M.; Stangel, P. eds. Status and management of neotropical migratory birds. Gen. Tech. Rep. RM-229. Fort Collins, CO: USDA Forest Service:321-330.

Loman, J., and T. von Schantz. 1991. Birds in a farmland-more species in small than in large habitat island. Conser. Biol. 5:176-188.

Lovejoy, T.E., R.O. Bierregaard, Jr, A.B. Rylands, J.R. Malcolm, C.E. Quintela, L.H. Harper, K.S. Brown, Jr., A.H. Powell, G.V.N. Powell, H.O.R. Schubart, and M.B. Hays. 1986. Edge and other effects of isolation on Amazon forest fragments. In: Soule, M.E. ed. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Sunderland, MA:257-285.

Magurran, A.E. 1988. Ecological diversity and its measurement. Princeton Univ. Press, Princeton, NJ.

Malanson, G.P. 1993. Riparian landscapes. Cambridge Univ. Press, Cambridge.

Martin, T.E. 1988. Habitat and area effects on forest bird assemblages: is nest predation an influence? Ecology 69:74-84.

Martin, T.E. 1993. Nest predation among vegetation layers and habitat types: revising the dogmas. American Naturalist 141:897-913.

Martin, T.E. 1995. Avian life history evolution in relation to nest sites, nest predation, and food. Ecological Monographs 65:101-127.

Martin, T.E., and D.M. Finch (eds.). 1995. Ecology and management of Neotropical migratory birds: a synthesis and review of critical issues. Oxford University Press, New York. 416 p.

Merigliano, M.F. 1996. Ecology and management of the south fork Snake River cottonwood forest. U.S. Department of Interior, Bureau of Land Management, Technical Bulletin 96-6, Boise, Idaho.

Milchunas, D.G., and W.K. Lauenroth. 1993. Quantitative effects of grazing on vegetation and soils over a global range of environments. Ecological Monographs 63:327-366.

Mosconi, S.L., and R.L. Hutto. 1982. The effect of grazing on the land birds of a western Montana riparian habitat. Pages 221-233 in Wildlife-livestock relationships symposium: proc. 10 (J.M. Peek and P.D. Dalke, eds.). Univ. of Idaho For. Wildl. Rante Exp. Sta., Moscow, Idaho.

Ohmart, R.D. 1994. The effects of human-induced changes on the avifauna of western riparian habitats. Studies in Avian Biology 15:273-285.

Ohmart, R.D., and B.W. Anderson. 1986. Riparian habitat. Pages 169-199 in Inventory and monitoring of wildlife habitat (A.Y. Cooperrider, R.J. Boyd, and H.R. Stuart, eds.). USDI Bur. Land Manage. Service Center. Denver, Colorado.

Peterjohn, B.G., J.R. Sauer, and C.S. Robbins. 1995. Population Trends from the North American Breeding Bird Survey. In: Finch, D.M.; Martin, T.E. eds. Ecology and management of neotropical migratory birds: a synthesis and review of critical issues. Oxford Univ. Press:3-39.

Platts, W.S. 1991. Livestock grazing. Influences of forest and rangeland management on salmonid fishes and their habitats. Amer. Fisheries Soc. Spec. Publ. 19:389-423.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. BioScience 47:769-784.

Pulliam, H.R. 1988. Sources, sinks, and population regulation. American Naturalist 132:652-661.

Ralph, C.J., G.R. Geupel, P. Pyle, T.E. Martin, and D.F. DeSante. 1993. Field methods for monitoring landbirds. USDA For. Serv. Gen. Tech. Rep. PSW-GTR-144.

Rappole, J.H. 1995. Ecology of migrant birds: A Neotropical perspective. Smithsonian Institution Press. Washington, DC. 504 p.

Robbins, C.S. 1980. Effect of forest fragmentation on breeding bird populations in the Piedmont of the Mid-Atlantic Region. Atlantic Naturalist 33:131-136.

Robbins, C.S.; Sauer, J.R.; Greenberg, R.; Droege, S. 1989a. Population declines in North American birds that migrate to the Neotropics. Proceedings of the National Academy of Sciences 86:7658-7662.

Robbins, C.S., D.K. Dawson, and B. A. Dowell. 1989b. Habitat area requirements of breeding forest birds of the Middle Atlantic States. Wildl. Monogr. 103:1-34.

Robertson, R.J., and N.J. Flood. 1980. Effects of recreational use of shorelines on breeding bird populations. Canadian Field Naturalist 94:131-138.

Rodenhouse, N.L., L.B. Best, R.J. O'Connor, and E.K. Bollinger. 1995. Effects of agricultural practices and farmland structures. In: Finch, D.M.; Martin, T.E. eds. Ecology and management of neotropical migratory birds: a synthesis and review of critical issues. Oxford Univ. Press:269-293.

Rood, S.B., and S. Heinze-Milne. 1989. Abrupt downstream forest decline following river damming in southern Alberta. Can. J. Bot. 67:1744-1749.

Saab, V.A. 1996. Influences of spatial scale and land-use practices on habitat relationships of breeding birds in cottonwood riparian forests. Ph.D. Dissertation. University of Colorado, Boulder, Colorado.

Saab, V.A. 1999. Importance of spatial scale to habitat use by breeding birds in riparian forests: a hierarchical analysis. Ecological Applications 9 (1).

Saab, V., and C. Groves. 1992. Idaho's migratory landbirds: description, habitats, and conservation. Idaho Wildlife 12:11-26.

Saab, V.A., and T.D. Rich. 1997. Large-scale conservation assessment for Neotropical migratory landbirds in the Interior Columbia River Basin. USDA Forest Service Gen. Tech. Rep.PNW-GTR-399 Pacific Northwest Research Station, Portland, OR, 56p.

Saab, V.A., C.E. Bock, T.D. Rich, and D.S. Dobkin. 1995. Livestock grazing effects in western North American. In: Finch, D.M.; Martin, T.E. eds. Ecology and management of neotropical migratory birds: a synthesis and review of critical issues. Oxford Univ. Press:311-353.

SAS Statistical Institute. 1990. SAS/STAT user's guide. Vol. 2. Version 6, 4th ed. SAS Statistical Institute, Cary, NC.

SAS Statistical Institute. 1993. SAS/INSIGHT user's guide. Version 6, 2nd ed. SAS Statistical Institute, Cary, NC.

Schulz, T.T., and W.C. Leininger. 1991. Nongame wildlife communities in grazed and ungrazed montane riparian sites. Great Basin Natur. 51:286-292.

Sedgwick, J.A., and F.L. Knopf. 1987. Breeding bird response to cattle grazing of a cottonwood bottomland. J. Wildl. Manag. 51:230-237.

Society of Range Management. 1989. A glossary of terms used in range management. Society of Range Management, Denver, CO.

Stauffer, D.F., and L.B. Best. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. J. Wildl. Manage. 44:1-15.

Szaro, R.C., and J.M. Jakle. 1985. Avian use of a desert riparian island and its adjacent scrub habitat. Condor 87:511-519.

Temple, S.A., and B. Wilcox. 1986. Predicting effects of habitat patchiness and fragmentation. In: Verner, J., M.L. Morrison, and C.J. Ralph. eds. Wildlife 2000: modeling habitat relationships of terrestrial vertebrates. Univ. Of Wisconsin Press, Madison, WI:261-262.

Terborgh, J. 1989. Where have all the birds gone? Princeton Univ. Press, Princeton, New Jersey.

Thomas, J.W., C. Maser, and J.E. Rodiek. 1979. Wildlife habitats in managed rangelands - the great basin of southeastern Oregon. USDA Forest Service Gen. Tech. Rep. PNW-80. Pacific Northwest Forest and Range Experiment Station, Olympia, Washington.

Titus, J.R., and L.W. VanDruff. 1981. Response of the common loon to recreational pressure in the Boundary Waters Canoe Area, northeastern Minnesota. Wildl. Monograph 79:1-58.

van der Zande, A.N., and P. Vos. 1984. Impact of semi-experimental increase in recreation intensity of the densities of birds in groves and hedges on a lake shore in The Netherlands. Biological Conservation 30:237-259.

van der Zande, A.N., J.C. Berkhuizen, H.C. van Latesteijn, W.J. ter Keurs, and A.J. Poppelaars. 1984. Impact of outdoor recreation on the density of a number of breeding bird species in woods adjacent to urban residential areas. Biological Conservation 30:1-39.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manag. 47:893-901.

Verner, J. 1985. Assessment of counting techniques. Current Ornithol. Vol. 2:247-302.

Whitcomb, R.F., C.S. Robbins, J.F. Lynch, B.L. Whitcomb, M.K. Klimdiewicz, and D. Bystrak. 1981. Effects of forest fragmentation on the avifauna of the eastern deciduous forest. Pages 125-205 in: R.L. Burgess and D.M. Sharpe, editors. Forest Island Dynamics in man-dominated landscapes. Springer-Verlag, New York, NY, USA.

Whitfield, M.B., and M.E. Maj. 1998. Inventory and monitoring of bald eagles and other raptorial birds of the Snake River, Idaho. U.S. Department of Interior, Bureau of Land Management, Technical Bulletin 98-2. Boise, Idaho.

APPENDIX.1. Species used for data analysis and recorded within point count circles during 1991-1994, May-July along the South Fork Snake River in southeastern Idaho. Letters in parentheses after the common name indicate migratory status: L = long-distance neotropical migrant; S = short-distance neotropical migrant; R = resident. The letter "C" in parentheses after the scientific name indicates that the species nests in tree cavities; all other species are open-cup nesters. Total number of patches is the number of cottonwood patches from a total of 57 in which a species was recorded.

| Common name | Acronym | Scientific name | Nest Layer[a] | Total No. Patches |
|---|---|---|---|---|
| American Kestrel(S) | AMKE | *Falco sparverius(C)* | CA | 24 |
| Mourning Dove(L) | MODO | *Zenaida macroura* | SH | 50 |
| Yellow-billed Cuckoo(L) | YBCU | *Coccyzus americanus* | CA | 5 |
| Red-naped Sapsucker(L) | RNSA | *Sphyrapicus nuchalis(C)* | CA | 43 |
| Hairy Woodpecker(R) | HAWO | *Picoides villosus(C)* | CA | 10 |
| Downy Woodpecker(R) | DOWO | *Picoides pubescens(C)* | CA | 38 |
| Northern Flicker(S) | NOFL | *Colaptes auratus(C)* | CA | 50 |
| Eastern Kingbird(L) | EAKI | *Tyrannus tyrannus* | CA | 12 |
| Western Wood-pewee(L) | WWPE | *Contopus sordidulus* | CA | 40 |
| Dusky Flycatcher(L) | DUFL | *Empidonax oberholseri* | SH | 26 |
| Black-billed Magpie(R) | BBMA | *Pica pica* | SH | 46 |
| American Crow(R) | AMCR | *Corvus brachyrhynchos* | CA | 27 |
| Black-capped Chickadee(R) | BCCH | *Parus atricaphillus(C)* | CA | 51 |
| House Wren(L) | HOWR | *Troglodytes aedon(C)* | CA | 39 |
| Gray Catbird(L) | GRCA | *Dumetella carolinensis* | SH | 37 |
| American Robin(S) | AMRO | *Turdus migratorius* | CA | 57 |
| Veery(L) | VEER | *Catharus fuscenscens* | GR | 34 |
| Cedar Waxwing(S) | CEWA | *Bombycilla cedorum* | SH | 43 |
| European Starling(R) | EUST | *Sturnus vulgaris(C)* | CA | 44 |
| Warbling Vireo(L) | WAVI | *Vireo gilvus* | CA | 42 |
| Red-eyed Vireo(L) | REVI | *Vireo olivaceous* | CA | 11 |
| Yellow Warbler(L) | YEWA | *Dendroica petechia* | SH | 57 |
| Yellow-rumped Warbler(S) | YRWA | *Dendroica coronata* | CA | 32 |
| MacGillivray's Warbler(L) | MGWA | *Oporornis tolmiei* | SH | 26 |
| Yellow-breasted Chat(L) | YBCH | *Icteria virens* | SH | 12 |
| Western Tanager(L) | WETA | *Piranga ludoviciana* | CA | 27 |
| Black-headed Grosbeak(L) | BHGR | *Pheucticus melanocephalus* | SH | 46 |
| Lazuli Bunting(L) | LZBU | *Passerina amoena* | SH | 34 |
| Northern Oriole(L) | NOOR | *Icterus glabula* | SH | 54 |
| Brown-headed Cowbird(S) | BHCO | *Molothrus ater* | SH | 50 |
| Cassin's Finch(S) | CAFI | *Carpodacus cassinii* | CA | 19 |
| American Goldfinch(S) | AMGO | *Carduelis tristis* | CA | 56 |

[a] Nest Layer abbreviations: CA=subcanopy/canopy nesting species; GR=ground-nesting species; SH=shrub-nesting species based on characteristics described by Ehrlich et al. (1988), Martin (1993), and known nest locations within the study area (Saab, unpublished data).

APPENDIX 2. All bird species recorded within point count circles during 1991-1994 breeding seasons along the South Fork Snake River in southeastern Idaho. Species whose names are in bold (listed at the end) were observed outside of point count surveys or during surveys conducted by Whitfield and Maj (1998).

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| Double-crested Cormorant | *Phalacrocorax auritus* | Osprey | *Pandion haliaetus* |
| Great Blue Heron | *Ardea herodias* | Golden Eagle | *Aquila chrysaetos* |
| Sandhill Crane | *Grus canadensis* | Bald Eagle | *Haliaeetus leucocephalus* |
| Canada Goose | *Branta canadensis* | Red-tailed Hawk | *Buteo jamaicensis* |
| Mallard | *Anas platyrhynchos* | American Kestrel | *Falco sparverius* |
| Common Merganser | *Mergus merganser* | Northern Goshawk | *Accipiter gentilis* |
| Sora | *Porzana carolina* | Cooper's Hawk | *Accipiter cooperii* |
| Spotted Sandpiper | *Actitis macularia* | Sharp-shinned Hawk | *Accipiter striatus* |
| Killdeer | *Charadrius vociferus* | Ruffed Grouse | *Bonasa umbellus* |
| Red-necked Phalarope | *Phalaropus lobatus* | Rock Dove | *Columba livia* |
| Common Snipe | *Gallinago gallinago* | Mourning Dove | *Zenaida macroura* |
| Turkey Vulture | *Cathartes aura* | White-throated Swift | *Aeronautes saxatilis* |

APPENDIX 2. Continued.

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| Yellow-billed Cuckoo | *Coccyzus americanus* | Willow Flycatcher | *Empidonax traillii* |
| Black-chinned Hummingbird | *Archilochus alexandri* | Dusky Flycatcher | *Empidonax oberholseri* |
| Calliope Hummingbird | *Stellula calliope* | *Empidonax* sp. | *Empidonax* sp. |
| Belted Kingfisher | *Ceryle alcyon* | Tree Swallow | *Tachycineta bicolor* |
| Great Horned Owl | *Bubo virginianus* | Violet-green Swallow | *Tachycineta thalassina* |
| Common Nighthawk | *Chordeiles minor* | Northern Rough-winged Swallow | *Stelgidopteryx serripennis* |
| Red-naped Sapsucker | *Sphyrapicus nuchalis* | Bank Swallow | *Riparia riparia* |
| Hairy Woodpecker | *Picoides villosus* | Cliff Swallow | *Hirundo pyrrhonota* |
| Downy Woodpecker | *Picoides pubescens* | Barn Swallow | *Hirundo rustica* |
| Northern Flicker | *Colaptes auratus* | Black-billed Magpie | *Pica pica* |
| Eastern Kingbird | *Tyrannus tyrannus* | Common Raven | *Corvus corax* |
| Olive-sided Flycatcher | *Contopus borealis* | American Crow | *Corvus brachyrhynchos* |
| Western Wood-pewee | *Contopus sordidulus* | Mountain Chickadee | *Parus gambeli* |

APPENDIX 2. Continued.

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| Black-capped Chickadee | *Parus atricaphillus* | Cedar Waxwing | *Bombycilla cedorum* |
| Red-breasted Nuthatch | *Sitta canadensis* | European Starling | *Sturnus vulgaris* |
| Rufous Hummingbird | *Selasphorus rufus* | Solitary Vireo | *Vireo solitarius* |
| Broad-tailed Hummingbird | *Selasphorus platycercus* | Warbling Vireo | *Vireo gilvus* |
| House Wren | *Troglodytes aedon* | Red-eyed Vireo | *Vireo olivaceus* |
| Ruby-crowned Kinglet | *Regulus calendula* | Yellow Warbler | *Dendroica petechia* |
| Gray Catbird | *Dumetella carolinensis* | Yellow-rumped Warbler | *Dendroica coronata* |
| Townsend's Solitaire | *Myadestes townsendi* | Black-throated Gray Warbler | *Dendroica nigrescens* |
| American Robin | *Turdus migratorius* | MacGillivray's Warbler | *Oporornis tolmiei* |
| Swainson's Thrush | *Catharus ustulatus* | Orange-crowned Warbler | *Vermivora celata* |
| Veery | *Catharus fuscenscens* | Yellow-breasted Chat | *Icteria virens* |
| Hermit Thrush | *Catharus guttatus* | Common Yellowthroat | *Geothlypis trichas* |
| American Dipper | *Cinclus mexicanus* | Western Tanager | *Piranga ludoviciana* |

APPENDIX 2. Continued.

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| Black-headed Grosbeak | *Pheucticus melanocephalus* | House Sparrow | *Passer domesticus* |
| Lazuli Bunting | *Passerina amoena* | Cassin's Finch | *Carpodacus cassinii* |
| Green-tailed Towhee | *Pipilo chlorurus* | Pine Siskin | *Carduelis spinus* |
| Chipping Sparrow | *Spizella passerina* | American Goldfinch | *Carduelis tristis* |
| Dark-eyed Junco | *Junco hyemalis* | Red Crossbill | *Losiz curvirostra* |
| Western Meadowlark | *Strunella neglecta* | White-crowned Sparrow | *Zonotrichia leucophrys* |
| Red-winged Blackbird | *Agelaius phoeniceus* | Fox Sparrow | *Passerella iliaca* |
| Yellow-headed Blackbird | *Xanthocephalus xanthocephalus* | Song Sparrow | *Melospiza melodia* |
| Brewer's Blackbird | *Euphagus cyanocephalus* | Evening Grosbeak | *Coccothraustes vespertinus* |
| Common Grackle | *Quiscalus quiscala* | **Swainson's Hawk** | ***Buteo swainsoni*** |
| Bullock's Oriole | *Icterus bullockii* | **Northern Harrier** | ***Circus cyaneus*** |
| Brown-headed Cowbird | *Molothrus ater* | **Peregrine Falcon** | ***Falco peregrinus*** |

APPENDIX 2. Continued.

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| **Prairie Falcon** | ***Falco mexicanus*** | | |
| **Northern Saw-whet Owl** | ***Aegolius acadicus*** | | |
| **Northern Pygmy-Owl** | ***Glaucidium gnoma*** | | |
| **Western Screech Owl** | ***Otus kennicottii*** | | |
| **Flammulated Owl** | ***Otus flammeolus*** | | |

**Bureau of Land Management**
Idaho State Office
1387 S. Vinnell Way
Boise, Idaho 83709

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